
Space Weather Technical Forecast

Issued on Sunday, 21 April 2024 at 01:13 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: R1/R2 Likely. Slight Chance G1 before UTC midweek.

Solar Activity: Solar activity, as measured at GOES16 and 18 fell to Low in the past 24 hours, with frequent mid-level C-class flares observed, peaking with a C7.5 from AR3645 at 20/1706UTC.

There are currently around twelve active regions, although the partitioning of the central cluster comprising ARs 3637, 38, 47, 45, 43 and 50 remains complex. The main regions on the disc at present in terms of complexity (on paper) are perhaps AR3637 in the north, which saw some areal growth and emergence of intermediate spots as well as a spreading tendency to reach Esi/Beta classification. AR3645 in the centre saw growth of peripheral spots and spreading to become an Eki/Beta-Gamma, with some possible tenuous candidates for Mt Wilson delta spots. The final main region of note in terms of complexity was AR3647, although the growth trend here was more stable, taking the form of a Dki/Beta by the time of this analysis.

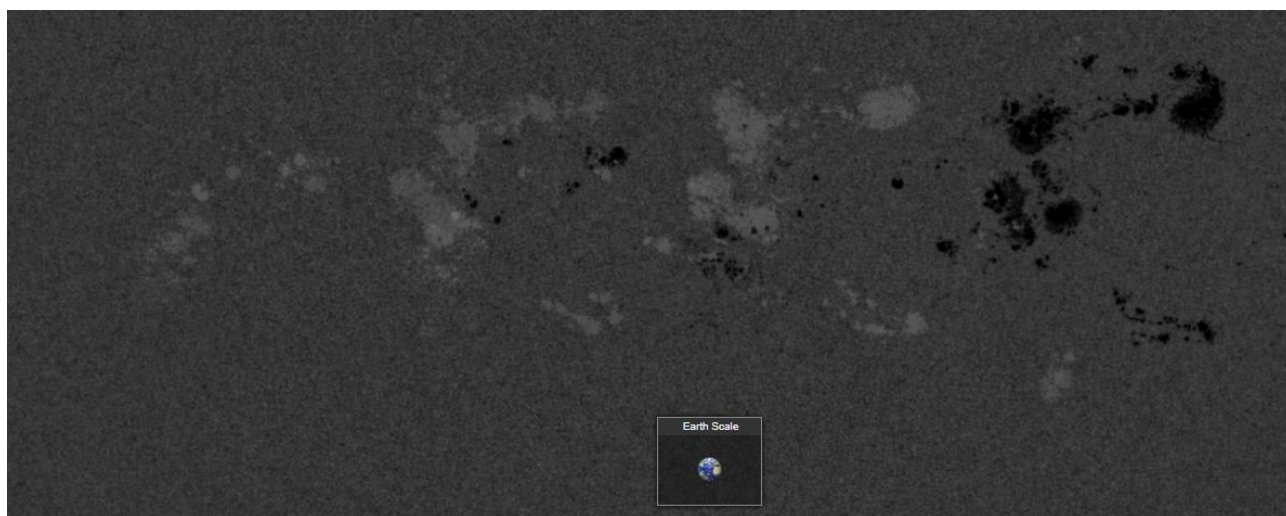


Figure 0: Helioviewer.org-derived HMIIF difference imagery for the past 48 hours, with black sunspot region footprints valid at 20/2300UTC, with previous appearances further east in white at 19/2300 and 18/2300UTC. Note the areal growth of AR3645 in the upper right of the group over this time interval, as well as the southeastern AR3647.

No new clear Earth-directed CMEs have been observed. The M1.0 flare CME of 19 April was analysed, however unpicking its influence from the many minor CMEs in MOSWOC Enlil is not possible - it is considered likely to add to the complexity of the forecast without dominating.

The main new CME event of the past 24 hours was perhaps an emission to the southwest from the immediate vicinity of apparently minor region AR3636. This was not clearly a filament on H-Alpha imagery, however it appears to originate from a magnetic neutral line. This feature has been analysed as determined to most likely miss the Earth. There were also a number of jet-like

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emissions seen in AIA304 from AR3637 at 20/1130UTC, and a number of events from AR3638 for several hours from 20/1500UTC. In the latter case, this repeats behaviour seen in recent days, and these are felt most likely to lie off the Sun-Earth line.

Solar Wind / Geomagnetic Activity: The solar wind as recorded by ACE at L1 was relatively turbulent, perhaps riding on or near the current sheet given frequent changes in phi angle, although this was perhaps slightly biased to negative territory overall (towards the Sun). There may be some influence of CH25/- in this signal.

Solar wind speeds showed a decreasing trend overall, falling through Slightly Elevated levels from near 500 to 400km/s. The solar wind density also fell over the same interval, remaining within single figures ppcc throughout. The IMF fell from an early high of 7nT to a more stable trend at or below 5nT with time, although the north-south component was perhaps the most notable feature, as although only small-scale between +3 and -5nT, it was largely anti-aligned with Earth's field between 20/0700 and 2130UTC.

The net result of the above solar wind measures was for provisionally Quiet to Active Kp indices, peaking with a Kp '4-' in the 09-12UTC interval.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) observed at GOES18 was at Background levels.

High energy electron flux (greater than 2MeV) observed at GOES16 was mainly at Normal Background levels. The associated 24-hour fluence remained below Active (1e8 integrated flux) with a value of 1.51e6 integrated pfu observed at 21/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: No significant regions are due to arrive or leave in the period, and M-class flares remain Likely, with a Slight Chance of X-class.

Solar Wind / Geomagnetic Activity: The geomagnetic forecast carries very low confidence in detail, however any enhancements are considered to peak in the G1/Minor Geomagnetic Storm range before midweek (UTC, and barring any new events).

There are a number of CMEs expected to pass near Earth, originating from the southeastern quadrant between 18 and 19 April, with the potential for weak glancing impacts between Sunday 21 and Tuesday 23 April. Otherwise, fast wind influence from CH25/- may become more reliable over the remainder of the current UTC weekend before gradually and erratically easing into the new UTC working week.

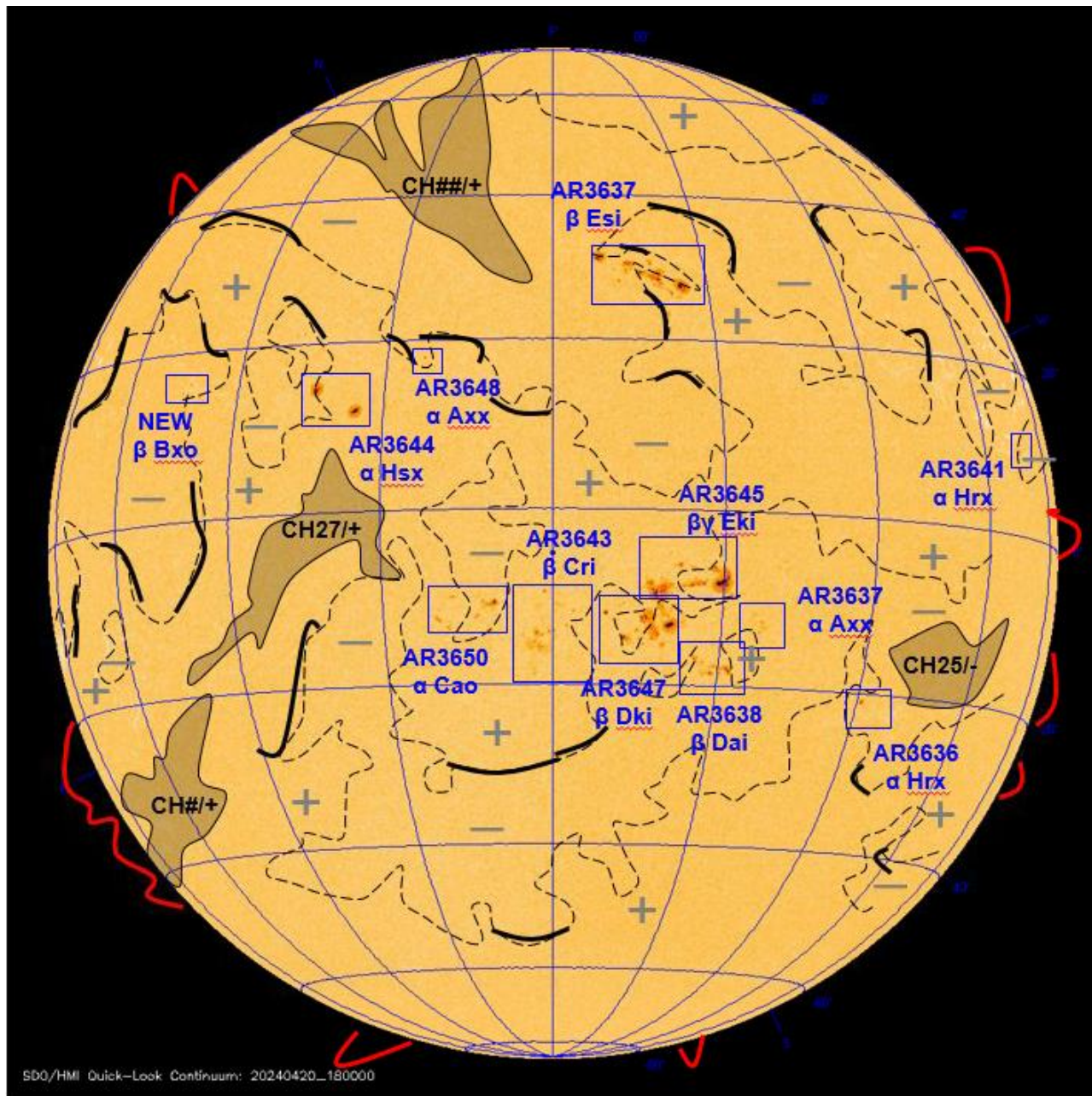
Geomagnetic activity is expected to be Quiet with Unsettled intervals for much of the period, however any additional enhancement from CME arrivals will bring the potential for Active to G1 Minor Storm intervals, perhaps most likely in the 72-hour period of the UTC days of Sunday and Tuesday (21 and 23 April).

Energetic Particles / Solar Radiation: High energy proton flux carries a slowly increasing Slight Chance of S1 due to the number of more complex sunspot regions moving into the western solar hemisphere.

High energy electron flux as observed by GOES16 is expected to rise to Moderate, perhaps High levels into the new UTC week, however this may be limited by any glancing CME impacts that occur. The associated 24-hour electron fluence is expected to remain below the Active (1e8 integrated pfu) threshold but with an increasing trend, and a Slight Chance of reaching Active into the new working week UTC - depending on the CME influence.

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Figure 1. Solar Analysis Valid 20/1800UTC.



Key: Filament ____, Prominence ____, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

The geomagnetic forecast carries very low confidence in detail, however any enhancements are considered to peak in the G1/Minor Geomagnetic Storm range before midweek (UTC, and barring any new events).

The current CME forecast has become difficult to unpick, with the MOSWOC Enlil ensemble showing a generally envelope of perturbed solutions between days one and three, i.e. minor CME arrivals are considered possible until the middle of the coming UTC working week (barring new events). None of these were emitted in the past 24-hour period, with the main source being jet-like CMEs from AR3638 to end the last working week (UTC).

The other main consideration of the coming forecast period is influence from CH25/-, which if present has been hesitant in the past 24 hours, however this becomes more likely over the remainder of the current UTC weekend. CH25 itself is a small feature and should therefore have a limited tenure before the fast wind gradually and erratically eases to background slow wind conditions into the start of the working week.

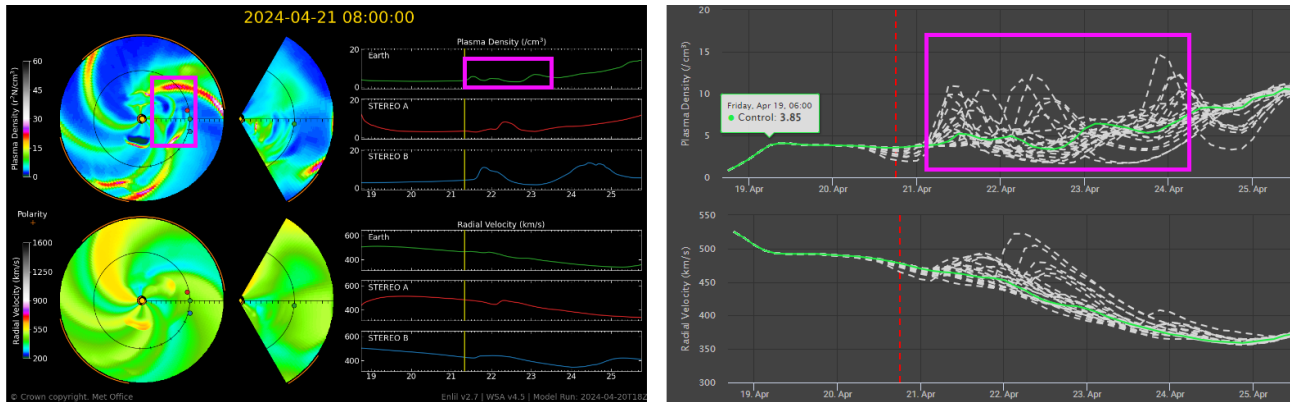
Geomagnetic activity is expected to be Quiet with Unsettled intervals for much of the period, however any additional enhancement from CME arrivals will bring the potential for Active to G1 Minor Storm intervals, perhaps most likely in the 72-hour period of the UTC days of Sunday and Tuesday (21 and 23 April).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	20	20	20	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Several CME candidates possibly inbound, all modelled as of glancing incidence and mainly passing 1AU between 21 and 23 April inclusive. Main sources are perhaps CMEs from AR3637 and 3638 in the period 18 and 19 April.

Figure 2: MOSWOC Enlil and Ensemble, badge time 20/1800UTC. The simulation has been paused around the time of arrival of one of many inbound glancing blows, with the period between 21 and 23 April (boxed magenta) showing a number of perturbed solutions from the decline from a minor fast wind (from CH25/-).



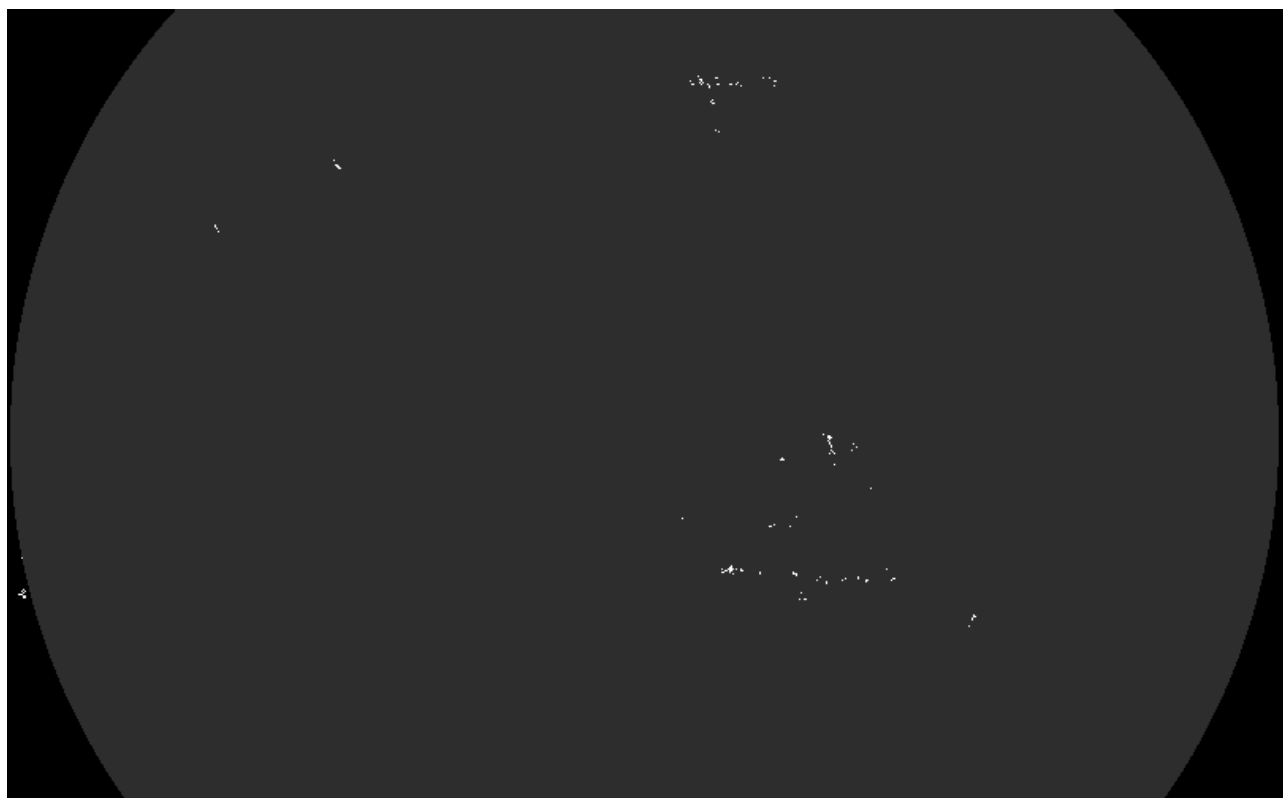
Radio Blackouts - X-Ray Flares:

The Pentiction 10.7cm value is currently slightly reduced on its high of 227sfu reached on Thursday 18 April, however it remains high at 210sfu, and this is largely the result of the large central mass of sunspot regions. The exact apportionment of this very large plage is somewhat subjective, however the regions are all now largely straightforward dipoles in magnetic imagery, which makes the process more straightforward. The possible main exception to this is AR3645 in the north of the group, which has shown a tendency to approximations of minor Mt Wilson delta spots, which when coupled with its Zurich complexity and penchant for producing jet-like CMEs makes it perhaps the spot group to watch at present. The other main groups are AR3637 in the northwest, and AR3647 in the south-centre. Both of these have filaments in relatively close proximity which are an additional source for possible CMEs as well as the regions themselves.

No significant regions are due to arrive or leave in the period, and M-class flares remain Likely, with a Slight Chance of X-class. Daily probabilities are held near the raw values for the disc - these figures are perhaps more reliable than average given the large number of regions and possible contributors.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	70	70	70	70
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: SIDC ROB flare locations above C-class, as recorded by PROBA-2. The main contributors can be seen to be AR3647, 45 and 37.



Solar Radiation Storms - (High Energy Protons):

High energy proton flux as observed by GOES18 has persisted at Background levels.

There is a gradually increasing Slight Chance of the solar radiation trace reaching S1 in response to any notable flares, as the large agglomeration of centre-disc active regions traverses westwards. There is no significant reducing contribution from any departed regions on the far side, and the overall trend is therefore slightly upwards in the period.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	10	15	15	15
Very Active	$\geq \text{S3}^*$	No	1	1	1	1

* $\text{S3} \geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)

High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux as observed by GOES16 has persisted at mainly Normal Background levels, with an enhanced solar wind environment due to the CME arrival of 19 April and also the possible hesitant coronal hole fast wind connection to CH25/-.

The above has likely increased electron populations at lower orbits, and as solar wind pressure eases into the new UTC working week, the observed flux at GEO is expected to increase to diurnally reach Moderate, perhaps eventually peaking at High flux. This rationale is low confidence however due to the chance of glancing CME arrivals which may serve to redistribute any increased counts.

The associated 24-hour integrated electron fluence is expected to persist below the Active threshold, but with a Slight Chance of approaching this level later in the period. This would most likely require inbound CME arrivals to miss, allowing the build up of flux.

MOSWOC REFM is not expected to offer useful guidance in the period given glancing CME influence, however should these all miss Earth, the upward trend in the next 72 hours is considered reasonable, albeit still peaking below Active.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	5	10	10
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 4: Latest MOSWOC REFM, showing forecast rising fluence towards Active in the coming 72-hour period – considered good guidance in the possible absence of intervening CME activity.

